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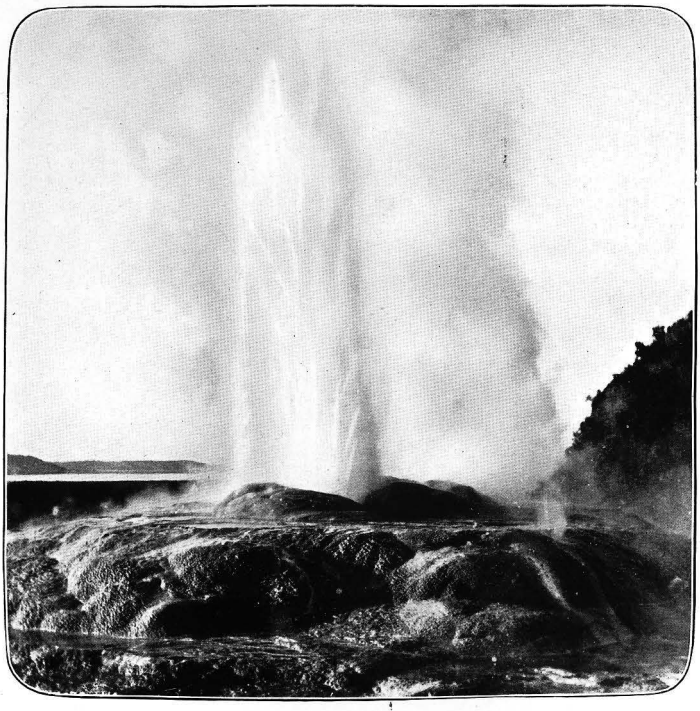

THE WAIKITI GEYSER, NEW ZEALAND.

(From a photograph by Mr. Iles, Rotorua, N.Z.)

ORDINARY MEETING.*

CAPTAIN HEATH, R.N., IN THE CHAIR.

The Minutes of the last Meeting were read and confirmed.

The following paper was read by the author :—

ON THE HOT LAKES DISTRICT, NEW ZEALAND.

By Miss HILDA BOORD. (*With photographic illustrations by kind permission of Mr. Josiah Martin, of Auckland, N.Z., of Messrs. Valentine and Sons, of Dundee, and of Mr. Iles, of Rotorua, N.Z.*)

HAVING been asked by Professor Hull to give an account of what I saw during my stay in that part of New Zealand which is most justly termed the Wonderland, I can but endeavour to comply with his request. I must confess at once, however, to being no scientist myself, and therefore I fear that my observations can have no more value than those of any other ordinary traveller; circumstances, moreover, prevented me from visiting some of the principal places of interest.

My best plan, I think, will be to take up my narrative from the time my sister and I left Pipiriki on the Wanganui River; a river so exquisitely beautiful in itself that it would be fatal to my present purpose to dwell upon its banks and describe its many charms.

It was in the New Zealand autumn, nearly three years ago, that we started one morning on our seven days' coaching trip across country to Rotorua from Pipiriki, a very small settlement formed, for the most part, of Maoris. They are very

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* Monday, February 8th, 1904.

unsophisticated still in this out-of-the-way neighbourhood, and we had opportunities of observing the native customs of the *hongi*, or salutation by nose-rubbing, and the *tangi*, or wailing, a very dismal performance.

Our road, such as it was, lay for half the day through beautiful bush, composed chiefly of the birch trees, as they are commonly called, though they are I think more nearly allied to the beech. They have a very minute leaf for such large trees, and there are at least three varieties, known to the settlers as black, red, and white birch. We were too far south for the Kauri Pine, which only grows in latitudes north of the city of Auckland. What strikes one most in coaching through the country are the great tracts of bush which have been burnt down. It is a melancholy sight to see the gaunt skeletons of bare, scorched, dead trees still standing, as it were, to form their own tombstones, reminding us of what they must once have been. There may be many good reasons for burning the bush in so ruthless a manner, and one is that it is the cheapest way of clearing the country from the settlers' point of view; and another, that it causes the undergrowth to spring up, thus providing fresh food for the sheep and cattle; though amongst it is often to be found the *tut*, or *tutu*, which is poisonous to sheep. The practice is said to be altering the climate of the country, though how this may be, of course, I do not know.

At last we emerged upon the beautiful Marumutu Plains. It was quite different scenery up here, and much colder. Passing through the small missionary station of Karioi, we came as far as Waiouru, where we put up for the night, continuing our journey next day. We no sooner got up on to these weird-looking plains, than we caught sight of the strange group of mountains that seem to rise suddenly out of their midst, I mean Mounts Ruapehu, Tongariro, and Ngaruhoe. The name *ruapehu* means "hole of dust and ashes." This mountain (9,009 feet—the highest in the North Island) is eternally snow-clad, and has a crater on the summit, with a lake, the water of which sometimes reaches boiling point. Notwithstanding this, however, the sides of the crater are mantled in ice and snow. A little further north is black Tongariro, with the cone-shaped, and also black, Ngaruhoe rising out of it, and emitting a small volume of black smoke every few minutes. Earlier in the day we should have caught a glimpse of Mount Egmont, or *Taranaki* (the native name meaning "naked spear"), about seventy miles

away to the west, but the air was not clear enough for us to see it at the time.

We were skirting these mountains for a day and a half. The roads were very heavy indeed just then owing to the late rains; and in dry weather they are as unpleasantly dusty, or powdery, for they are composed, as is all the soil of this district, of nothing but pumice. Whilst waiting next day on the shores of Lake Taupo, we filled our pockets with pieces of pumice-stone, which are as plentiful as pebbles on the sea-beach. The pumice is of a softer kind, however, than that which we are accustomed to use for inky fingers, and powders much more readily.

We were now some 3,000 feet above sea level, having risen from about 180 feet at Pipiriki. The Rangipo Plains, across which we now steered our way, are very deceptive, and take longer to cross than probably appears at first sight, as one continually comes upon deep ravines formed by rivers and streams, and which are not noticeable until quite nearly approached, on account of the ground above and up to the very edges of the gorges, being perfectly flat.

Far away in the bush on our right dwell the Kiwi, which is a brown-feathered fowl here, whereas the West Coast kiwi of the South Island, is a grey bird. They are said to be fast dying out. Wild horses also rove about in herds. I believe their name is legion, though we only saw a few. They originally escaped during, or were let loose after, the last Maori war. We passed and crossed several rivers of very uncanny propensities. In one place there are two rivers flowing side by side, and rising from springs within only a few feet of each other; one is a very strong alum river, and the other is strongly impregnated with sulphur, and they flow sometimes over, and sometimes underground.

On reaching Tokaanu, on the southern shore of Lake Taupo, we experienced the very curious sensation of driving along for the first time with boiling and bubbling pools of water and puddles of mud on either side of the road. I think we felt as if we had suddenly been transplanted to another planet, where Nature had gone awry, or, at least, where other laws, unknown to us, prevailed.

Next morning we crossed Lake Taupo, the largest lake in the North Island, and about 25 by 18 miles across; it is 500 feet deep, and quite as beautiful in its own way as are the Cold Lakes of the South Island. It is 1,211 feet above sea-level. The low range of volcanic mountains in the distance is very

fine; whilst Ruapehu, rearing his hoary head, and Ngaruhoe, steaming and black, rise from rocky Tongariro. We gradually left these behind us, to form a splendid background from the northern side of the lake.

We were now getting into the heart of the Hot Lake district. Without waiting to describe the very novel and unique inn at which we stayed at Taupo, I must just mention that through the grounds—which are themselves contained in a round basin of rock some 40 feet deep and of about 4 or 5 acres space—flows a steaming-hot alum and sulphur stream, with a bath-house fitted up at one end. There are other pools and baths, less hot, in different nooks and corners where visitors bathe in novel, if rude luxury, for the dressing-sheds were then of the most primitive description.

My sister went that day to see the "Crow's Nest," a geyser which throws up its water at an angle of 45 degrees and from 20 to 80 feet high. I did not accompany her, as I was reserving my energies for the more famous Wairakei Valley, which we were to visit next day.

Before going further, it may be as well to mention that the principal places I visited during my stay in the Hot Lake District were Wairakei, and Rotorua (under which heading I may include Whakarewarewa and Ohinemuto). At Wai-o-tapu, I regret to say, we did not stay long; still more do I regret not having visited Tikitere; and most of all must I always mourn having omitted to pay homage to that king of geysers, Waimangu. I shall, nevertheless, have a few words to say about him later on.

But in those places and districts which I did visit, we saw as good specimens of the various moods in which volcanic forces in a moribund condition show themselves as, I suppose, are to be seen in all the world. The different forms these moods take may, for my present purpose, be placed under six headings, namely:—

(1) Hot springs.
(2) Low-pressure steam jets.
(3) Mud volcanoes.
(4) Fumaroles.
(5) Explosion craters.
(6) Geysers.

At Wairakei (where we will now take our stand) we found all these in profusion, and comprised in a valley about half a mile long, barely a quarter of a mile across, and between steaming sinter cliffs rising from 60 to 100 feet high. It is all most

beautifully wooded and wild, and luxuriant in fern and moss. The valley lies north-west by west, and south-east by east, and has the hot stream Te Wairakei running through it and finally emptying itself into the Waikato river. Of course this stream is fed by numerous hot springs all along its course, as well as by the outpourings of at least seventeen geysers in the valley.

Under our first heading of "hot springs" I must mention the numerous pools of various sorts that we here saw, whose colour, consistency, etc., are due, of course, to the chemical, or mineral, properties of the soil and subsoils through which the springs issue. There are blue pools, opal, or variously tinted pools, white pools of the consistency of cream, and which are formed of the finest fuller's earth to be found in the world. This last is a white clay held in suspension, and looking like pools of hot milk. Then there are vermilion-coloured streams and yellow-ochre streams, each flowing over beds of the clays from which painters procure two of their most effective colourings; but of course, vermilion paint is otherwise obtained as well.

Then I must mention the terraces of brittle sinter over which flow numerous small streams, always hot, and each imparting its own colour to the deposit—glistening white, dark red, of brown, pale yellow and cream-colour. We saw better examples of sinter terraces, however, at Whakarewarewa, near Rotorua. It is said that in time they may equal the pink and white terraces which, together with part of Lake Rotomahana, disappeared in the great Tarawera eruption in 1886. But surely the subterranean forces which were at work to form these famous terraces are scarcely in a condition likely to reproduce them? For, appalling as the catastrophe undeniably was, there was no mention of lava having been ejected, and therefore, I suppose, it cannot be classed as a *true* volcanic eruption. On the other hand, however, the conditions now existing may, as far as I know, be perfect for the reproduction of terraces which may vie with the departed ones, if only those conditions continue to exist long enough. That Nature has not yet exhausted her powers in those regions we are well aware, owing to the very recent appearance of the mighty geyser we are to consider presently.

Of the Low-Pressure Steam Jets I can here take but little notice, as we simply lived amongst them for three months. It is these which cause the steaming creeks and cliffs, and the hundreds of boiling or nearly boiling pools which make walking in the manuka scrub an exercise to be performed with "caution and good heed." I may remark in passing that a

Maori child fell into one of these pools, during our stay at Rotorua, and was so badly scalded that it did not recover. There is a story told, too—and I have no reason to doubt its truth—of an unfortunate man (he gave a church to the Maoris at Tokaanu, which he built with his own hands, by the way), who was walking home one night when he missed his path, and was found, boiled, in one of the hot pools next morning. It is in these boiling pools that the Maoris wash their clothes, and it is in this steaming earth that they make their *hangi* or earth-ovens. If you but push your stick into the bank by which you happen to be walking, or perchance sitting, as we were in the Wairakei Valley, the ferns hanging all about us moist with condensed steam, this all-pervading steam escapes from the hole you have made.

Mud-volcanoes are to be seen here and also at Whakarewarewa and Ohinemuto. Mr. Josiah Martin, F.G.S. (to whom I am indebted for some of these photographs), thus describes their formation in a paper printed in Messrs. Thomas Cook and Sons' Handbook to New Zealand, and from which I have refreshed my memory:—

"The continued escape of steam through soft rocks assists their decomposition into clay of various colours; and around the centre of action will be formed pits, cauldrons, craters, or cones, according to the consistency of the material ejected."

I well remember at Ohinemuto we saw a most extraordinary mud volcano throwing black mud into all sorts of fantastic shapes, such as marks of interrogation or interjection, or, again, into the form of a skull! We tried the effect of throwing in great lumps of earth, but though it stopped its play for a few moments, it was soon absorbed and the play was more eccentric than before. The "Brain Pot" is a famous mud volcano, which we saw at Whakarewarewa, in which the Maoris used (not so very long ago) to boil their enemies' heads.

Except for one fumarole, or blow-hole, which we saw in the Wairakei Valley (where we are still supposed to be stationed, though I wander away occasionally), I do not remember seeing any other which I can so classify. And this one had a small tubular opening down which the guide rammed the branch of a tree, which was boiled to nothing in less time than it takes me to describe the proceeding. Sometimes, however, the branch would be promptly ejected with a shriek, or whistle, on the part of the fumarole. This one is, if I remember rightly, known as the "Whistler." The "Devil's Trumpet" at Karapiti is the finest fumarole in the country, and is said by

Sir James Hector to be the safety-valve of New Zealand; but White Island also claims that distinction.

Explosion craters are most extraordinary. We saw, or more correctly speaking, heard, one at Wai-o-tapu as we were walking warily by the alum cliffs and over the brilliant yellow-crusted ground and amongst the many wonders there to be seen, when we were suddenly startled by an explosion just under the earth at our very feet. And we saw another at Whakarewarewa, called the "Torpedo." It is so named from its position under a stream, where it keeps throwing up large mud bubbles with a loud explosion each time.

And now we come to our most important subject, namely, Geysers. But how shall I describe them? To say that they are wonderful, beautiful, and even awful, beyond description, seems to me to be using words which can convey but little meaning to those who have never been fortunate enough to see them for themselves. I suppose—indeed, I am sure—that familiarity, even with the Hot Lake District, may to a certain extent breed contempt. For, on our first arrival at Rotorua, where geysers were playing all around us, and where the air was heavy and laden with strong sulphur fumes, I well remember wondering, with an uncanny feeling, whether during the night a new geyser might not burst up under the very house in which we dwelt! But before we left we slept as peacefully through minor shocks of earthquake as we should here in England through an insignificant thunder-storm. But, whilst the sense of fear may abate, the sense of awe and wonder at these marvellous displays of the effects of subterranean heat can only be stimulated and ever increased by the privilege of a closer acquaintance with Dame Nature in her wrathful moods.

Mr. Josiah Martin, to whom I have already referred, mentions three distinct types of geyser action, as represented in this district, namely, the intermittent, the periodical, and the explosive.

The intermittent geysers, are, of course, those in which the accumulations of steam are liberated with a sudden outburst of activity, very short in duration, and at uncertain intervals. The "Crow's Nest" geyser at Taupo, already mentioned, is a specimen of this type. I must have seen many others of this class, but I cannot remember them with sufficient distinctness to give them their names.

But of periodical geysers we saw several in the Wairakei Valley alone. We were hastened from one spot to another by the guide, who knows exactly at what moment any particular

geyser will be playing, also whether an intermittent geyser is likely to be playing between times. We saw, for instance:—

The Petrifying Geyser, plays high	every	2	hrs.	25	mins.
The Twins	„	„	„	41½	„
The Eagle's Nest	„	„	„	30	„
Great Wairakei	„	„	„	8	„
Dragon's Mouth	„	„	„	5	„

Feather plays often, but goes high every 2 hours.

Pack-Horse, Heron's Nest, and Black Geysers, etc., are irregular.

The "Pack-Horse" geyser is so named because it sprang up at a spot where a pack-horse plunged about, at last putting his hoof through the treacherous ground, much to his hurt, if not to his destruction.

Mr. Martin classifies "Pohutu" at Whakarewarewa as a periodical geyser: "the finest geyser in the country," he says; but he had not, of course, then heard of "Waimangu." But, after a three-months' sojourn within two miles of "Pohutu" I find it necessary to differ from him; at least, I do not understand Mr. Martin in designating "Pohutu" a periodical geyser. For during all that time it never played at regular intervals, and by everyone in the neighbourhood it was considered very erratic indeed. I must own, however, that Mr. Martin says, "Its discharge, *when not interfered with*, occurs at regular periods, and will continue as a beautiful display for two or even three hours." I may add that Pohutu throws its water to a height of 100 feet when at its highest. Now the means of interference with the play of a geyser may be natural, or it may be artificial. It is well known in the Hot Lake District of New Zealand that the action of one geyser in the neighbourhood will often determine the action of another; or, on the other hand, it may alter or prevent its play altogether. For instance, if one geyser, situated on a certain volcanic crack of the earth's surface, be particularly lively, it may exhaust some of the motive-power which would otherwise be expended on another geyser situated further along that crack, unless, as sometimes happens, *all* the geysers in that neighbourhood are particularly lively at the same time, which activity is specially noticeable after heavy rainfalls. My crude, and no doubt unscientific, mode of expression may very possibly make the facts I saw and noted appear to clash with Professor Bunsen's Tube theory, which, it seems, would point to the absolutely independent action of each separate geyser. I may, however, be quite wrong in my surmise; at any

rate, I will leave it to more competent heads than mine to fit square facts into round theories.

The artificial method of interfering with a geyser's play is to "soap" it. I am not aware that this habit of soaping geysers is generally known in England. The "Great Wairoa Geyser" at Whakarewarewa is situated perhaps 10 or 20 yards from "Pohutu," and for some reason or other has ceased to play naturally. Some say it is only since the railway was made: but as the railway is some distance off, I can see no reason for holding it accountable. The apparently worn-out geyser is, therefore, soaped occasionally. That is to say, several bars of soap are thrown into its mouth, forming a crust as they melt which keeps in the heat for some minutes (say eight or ten) after which the accumulated heat gathers sufficient strength to burst through the soap, and the geyser ejects its contents about 80 feet high. "Pohutu," however, from its natural formation does not lend itself to being soaped. But it is quite possible that soaping the "Great Wairoa" may materially interfere with the behaviour of "Pohutu." I may say that the soaping of the geyser is only allowed to be performed by the Government Officials, under whose supervision they are placed.

Explosive geysers are very well represented in the Wairakei Valley. The "Great Wairakei Geyser," which may be taken as a type, has a deep, funnel-shaped basin. After a short period of rest, the water rises rapidly with a deep, gurgling roar, then the contents surge up in steaming waves. This is followed by a powerful upheaval, in the form of a dome, of the whole contents of the basin. From this mass, when relieved from tension, there suddenly flashes in various directions explosive outbursts of steam and spray. After this violent display of energy, the water sinks once more into the basin, or perhaps is withdrawn into the tube, to repeat the same phenomena after an interval of six or eight minutes.

This description is quoted from the same authority, Mr. Martin: my own acquaintance with the wonderful Wairakei Valley having been made in one morning, I may perhaps be excused for coming away somewhat dazed and bewildered, and with but a confused idea of all I had seen.

I have, however, a very clear recollection of the "Champagne Cauldron." We descended to it by steps in a rock, and still further below us was a circular basin, about 70 feet across, and in perpetual ebullition. The guide took me to a ledge of rock overhanging the basin, where we seated ourselves and waited events. Presently, we felt a rhythmical tapping and throbbing

of the ground beneath us, and, simultaneously, the water began to rise higher—6 or 8 feet—a seething mass of sparkling hissing foam, with small fountains playing all round its swollen surface. Needless to say, we were at once enveloped in dense clouds of steam. To say that a person falling into this Cauldron would be scalded to death, is to put the matter very mildly; the victim would be absolutely boiled to shreds in a very few moments.

It would be most dangerous, and well-nigh impossible, to visit this valley without a guide. The geysers are not only difficult of access, and often hidden (when at rest) in the manuka and fern, but also in some places it is necessary to climb over the brittle sinter formation surrounding one geyser in order to reach another. And in doing this, we had to step across gaps and yawning chasms where the heat of the issuing steam was so intense as to make us greatly accelerate our pace. To be caught by a geyser would be more dangerous and less comfortable than to be caught by the in-coming tide.

We have seen that there is one called the "Petrifying Geyser." But, as far as I remember, petrifaction is a property common to all geysers (correctly so named) in New Zealand. This particular one, however, was no doubt more highly impregnated with soda, thus enabling it to deposit a greater amount of silica, which forms the beautiful rock known as siliceous sinter. The surroundings over which this geyser plays are composed of petrified manuka, fern, moss, and beech (or birch) tree. The "Eagle's Nest" geyser also has the gift of turning all it touches, not into gold, but into a most delicate coral-like substance. In its action it brings down the branches of any trees within reach, and they have quite the appearance of a huge nest which, under the spell of the petrifying, all-pervading silica, takes a fairy-like fawn-coloured tint and a frosted appearance, which are extremely pretty.

But I might speak of a hundred-and-one other wonders that we saw, not only here, but at Wai-o-tapu, at Rotorua, and at Whakarwarewa, but time forbids; and I must hasten on to that mighty new geyser which made its first appearance in January, 1901, just after our arrival in New Zealand. Or, at any rate, it was discovered and first brought to notice then by a Dr. Haines; and I think we may safely say that it is by far the finest geyser in the world. This geyser is called "Waimangu" (meaning "black water"), and is situated about seventeen miles from Rotorua, or half-way between that place and Wai-o-tapu, but not by the ordinary route. The "Waimangu," which belongs to the explosive type of geyser, has chosen to

spring up in the desolate regions which were once the home of the far-famed Pink and White Terraces, both of which, together with half of the Tarawera Mountain, disappeared in the great eruption of 1886, which also much reduced the size of Lake Rotomahana. The surrounding country is weird beyond description, scored as it is by ancient flows of lava. The whole of the neighbouring district is said to have benefited (from an agricultural point of view) by the last eruption, owing to the rains which followed it, and which converted the layer of ashes and fine dust which had been distributed over the land into a muddy soil which much improved it for productive purposes.

During our stay at Rotorua—which lasted three months—the "Waimangu" was playing every two or three days for several hours at a time. I was unable to visit it myself and, unfortunately, on the occasion of my sister's expedition thither, "Waimangu" proved sulky and would not play at all. I shall therefore do best, I think, to read an account from one of the Auckland papers, given by an eye-witness and one well acquainted with geyser-action in its every variety, namely, by the Wairakei guide whom I have already mentioned.

The paper is dated June 29th, 1901.

"A party of four, consisting of Mr. Parker, Mr. R. Graham, Mr. Scholtz and myself, pitched camp and ascended Mt. Kakaramea on the afternoon of the 24th of April last, to obtain a view of the country generally and to mark off the principal volcanic lines in the neighbourhood on the map, preparatory to visiting the Great Waimangu Geyser the following day. We arrived near the geyser about 9 a.m. next day. We found it quiet, but evidently approaching steaming point by the amount of vapour given off. Having obtained a fair idea of the height of the cliff on the south-east side (about 200 feet) and wishing to reach a position over the fissure line passing under the geyser from the direction of White Island and Tarawera, in order to time the pulsation during her play, we crossed over the boiling river marked on the map, and found the temperature 140 degrees Fahr. The stream of water would just about fill a flume 16 inches wide and 7 inches deep, clearly showing that a large amount of steam was undergoing condensation. We then ascended the hill behind the Inferno Crater, which contained a small lake of water, the depth of which we did not obtain, but we estimated its area at about 90 yards long and 40 or 50 yards wide (almost as large as that of the geyser). On the top of the hill we found another small

dry crater not named on the map, and sitting down on the summit, we lit our pipes and obtained a good view of Lakes Rotomahana and Tarawera, of Mt. Tarawera, and of the steaming rocks in our immediate neighbourhood, all on the line of the fissure which was blown out in 1886.

"Having enjoyed half-an-hour's rest, we felt the hill shake heavily beneath us, and away we went as fast as we could down to the foot of the hill near by the geyser, sitting down in such a position that we could watch the Inferno Crater Lake on our right hand, the boiling creek on our left, and the geyser in front. Mr. Graham had scarcely erected his camera when the hill was again severely shaken, and the subaqueous geyser (Torpedo) in the Inferno Crater began to crack like volleys of musketry. The water in the geyser basin began to spring, keeping perfect time with the Inferno Lake which was doing likewise. Twenty-eight seconds after the Torpedo exploded, and the geyser gave the first shot, and play commenced. It threw a vast body of water and black sand about 10 feet. Nine minutes after another shot 20 feet; 9 minutes later 30 feet, always increasing in height, until in perhaps three-quarters of an hour she appeared to obtain her greatest height, 200 feet or a little over, and kept this up every 9 minutes for at least half an hour, when it subsided to what I can best describe as a 20-feet boil. When the geyser obtained its maximum height it was discharging a great torrent of water at a temperature of 180 degrees Fahr., having risen 40 degrees since we crossed it before play. The temperature of the Inferno Lake was 110 degrees Fahr., and the pool was springing at least 10 inches. As the water line shows, it has been springing 4 feet or 5 feet, it is evident that it must have been throwing its load far beyond 1,000 feet high sometimes. So correctly did the play follow the amount of spring in the Inferno Lake, that any of us watching that, could safely say what the geyser shot would be 28 seconds later. I must say that it is by far the grandest geyser I have ever heard of, much less seen; a sight no man or woman will ever forget. I was delighted to find that it answers correctly to the pulsations of the earth recorded pretty well all over the world; at any rate, by seismograph in Japan, White Island, and Yellowstone Park, and felt repeatedly almost every day by myself on the pulsating cliff in the Wairakei Valley at intervals of four, five, and nine minutes. This is owing to the fact that the geyser is situated near the point of intersection of three fissures of the first, second, and third magnitude, and which are part of the

great thermal circulating system which extends over the whole earth, which radiates from its two thermal poles which lie near the equator, and are antipodes to each other.

"Owing to my excitement and delight at finding that the geyser answered in every respect to precisely the same general laws and habits of play as many others under my care, except upon a far grander scale, I came away without correctly measuring the amount of spring in the Inferno Lake. The height the geyser had been throwing its shot can be correctly estimated, and also an approximate estimate of the amount of force could be calculated, if the depth and area of the Inferno Lake could be obtained. However, its shot has far exceeded those witnessed by Mr. and Mrs. Haines, which I read in that excellent account by Mrs. Haines, published in your paper a few weeks ago, viz., 600 to 800 feet. We left the geyser about twelve o'clock, having been favoured with excellent weather, favourable wind and display. We could get and remain close enough to examine the machinery in its immediate neighbourhood, which all works like a band of music, with the Inferno Lake acting as conductor. It will impress the visitor with the might and power of Nature's forces."

Since that account was written, I have heard that the Waimangu geyser has taken to throwing up, not only gold quartz, but the raw material itself. But whether the report is authentic I cannot tell.

I have quite lately received accounts of the extraordinary eruption which occurred last August, when four persons lost their lives. But the accounts vary as to the height to which the geyser played: one saying 800 feet, others even greater. From the cross shoots observed during this eruption it is inferred that some of Waimangu's subterranean tubes must descend at considerable angles down into the earth.

Shortly before this great eruption the Government guide (whose brother was one of the victims) succeeded, with another man, in crossing the geyser's basin—of course during quiescence. The measurements of the basin were found to be 134 yards long by 80 broad, and the greatest depth sounded was 48 feet.

"Some idea of the force of the eruption of the geyser may be gathered from the circumstance that a photograph taken while it was playing shows a stone thrown up to an altitude of 1,800 feet, and the stone on falling was found to measure 8 feet by 12 feet." This seems doubtful.

In order to bear out the assertion that this new geyser is actually "by far the greatest in the world" it may be as well

to compare its highest shots of from 800 feet to 1,500 feet, with those of other known geysers. Here is the description given by Mr. Campbell of the play of the "Great Geyser," Iceland.

"It was a grand display, and well worth all the waiting. Instead of ending suddenly or gradually, the steam salute shot faster and faster; thuds followed each other rapidly, and the whole ground shook; then the sound of dashing water and the music of waves was added to the turmoil. A great dome rose in the middle of the pool, and frequent waves dashed over the edge of the basin, while streams overflowed and drenched the whole mound. Great masses of rolling steam burst out of the water-domes, and rose in the still air, swelling like white cumulus clouds against a hard blue sky. At last the whole pool, 50 odd feet wide, rose up, a single dome of boiling water, and burst; and then the column in the tube, 70 feet deep and 20 feet wide, was shot out of the bell-mouthed blunderbuss with a great burst of steam. The charge scattered; it rose about 80 feet, and most of it fell back and sank in with a rush; and so the glittering fountain rose thrice, like some mighty growth."

Professor Barrett, in whose article on geysers, in *Science for All*, I found the above quotation, goes on to say, the height to which the column of water is thrown has been variously estimated. The earliest records—a century ago—say 360 feet; but in modern times 100 feet seems to be the general opinion, and this has been confirmed by careful measurements made by competent observers.

In the Yellowstone National Park the three largest geysers, the "Grand," "Old Faithful," and the "Giantess" throw their waters respectively to the maximum height of 200 feet, 130 feet, and 250 feet. The "Beehive" may also be mentioned; it sends a spout 200 feet high.

When it is realized that in every case the steam of course rises many times higher than the water-shoot, of which we have been mainly thinking, a better idea may be gained of the magnificent spectacle presented by a geyser, even though it fall short of the stupendous heights reached by some of the monsters we have been considering.

A short description of White Island, mentioned above in the guide's account, may not be amiss here. It is from a New Zealand paper of three years ago:—

"White Island, the active volcano situated in the Bay of Plenty, some thirty miles off the coast, is one of the most remarkable islands in the world. It is in direct line with the

rest of the thermal region in New Zealand, and undoubtedly acts as a safety valve for the North Island. It is not often visited; but an excursion is annually run from Opotiki, from which it takes about three hours' steaming. Anchorage can only be got in one place, Crater Bay, in about fifty fathoms of water. At certain times, when the air is calm, enormous clouds of steam remain suspended over the island, and can be seen for miles. Arrived on the island, it is found that only the outside shell remains, the interior being occupied by a lake half a mile long and a quarter of a mile in breadth. The water of the lake is a beautiful green, and is composed of dilute hydrochloric acid, which is ruinous to cotton materials. Directly the water touches it the material loses all its colour and then falls to pieces. Parts of the lake are boiling, while other parts are cold. At times the water of the lake pours into the active crater and is rapidly ejected in clouds of steam. The lake is only six years old, and each year it increases in size, and the time seems not far distant when the island will be covered with water. The whole surface of the island is composed of sulphur of every possible tint, and some years ago a party of men were left on the island for the purpose of collecting sulphur for export. After a short stay they were so frightened by the awful surroundings and violent volcanic action that they could not be persuaded to remain any longer. It is said that a species of rat, red in colour, lives on the island and thrives on a small kind of crab. The fumes of the sulphur are in places overpowering, and walking is very dangerous, the safest way being to test every step with a stick before proceeding, as in many places the surface is merely a thin crust."

Before concluding, I should be very glad if anyone here could give, or suggest, a reason why the "Waimangu Geyser" sprang up so suddenly? And why it began by assuming such huge proportions? Assuming, on the "tube" theory, that it has a tube, it does not, I suppose, necessarily follow that the depth of the tube must be in proportion to the height of the geyser's play? I gather, rather, that it is the reverse; for the tube of the "Great Geyser" in Iceland, which is 76 feet deep (and has, I imagine, been growing from below, upwards) has taken, it is estimated, over 1,000 years to form, and we know that its play is on the decrease.

If then "Waimangu" already has a tube, why has it only so lately made its appearance? If it has as yet no tube, where does it hold the great bulk of water hurled into the air, together with huge rocks of a rhyolitic character every two or three days?

Am I right in surmising that the subterraneous heat must either here be specially near the surface, or, if at the base of a tube, the motive-heat must be extraordinarily great for it ever to reach the boiling-point of that (assumed) great depth, and to be capable of lifting so huge a bulk of water? The regularity of the geyser's shot, occurring, as it does, every nine minutes and rising ten feet higher each time, certainly seems to point to the existence of a tube of some depth. Is it possible that "Waimangu" is in reality an ancient geyser which, for some reason best known to Vulcan and his workmen, has been re-endowed with life?

Discussion.

The Chairman.—Ladies and gentlemen, I think that the new departure that the Secretary has spoken of in allowing a lady to read a paper here, you will, by the result of this afternoon, quite realize is a departure in the right direction, for we have had a most interesting paper, charmingly read.

It is a great many years since I was in New Zealand, but I have always had the most intense interest in the place from the peculiarity of the country altogether, and the remarkable volcanic conditions that exist all over it.

Many years ago I was in Tory Channel, which has an unenviable notoriety, as it was really the scene of the massacre of the crew of the *Tory* before the last New Zealand war. We were on a boating expedition, and we spent the night at the cottage of a settler there. We were talking about the country and earthquakes, and they said that on an average they had an earthquake once a month during the year. Just outside the city of Auckland there stands Mount Eden —an extinct volcano, the crater of which was almost as perfect as the day the volcano left off working. From the top of this cone there were to be seen, as far as I remember, thirteen not extinct volcanoes, probably, but volcanic cones. The whole country is full of interest from this very lively volcanic action that is going on.

No doubt there are many here who are interested in New Zealand, and I hope they will give us the benefit of their remarks.

Professor Logan Lobley, who is here, can, I think, give us some interesting remarks on the geological aspect of the country.

(The photographic slides were then exhibited on the screen.)

Professor LOGAN LOBLEY, F.G.S.—I am much obliged to you for the honour you have done me in asking me to take part in the discussion at so early a period of the evening.

I must congratulate the Institute on setting the example to other Societies by inviting a lady to read a paper on a scientific subject. I would also congratulate the author on giving us a most interesting and valuable paper respecting a district of such great physical interest.

The volcanic district of New Zealand, both of North Island and South Island, is very remarkable in one respect. I have in my mind compared the Rotorua district and the similarity with the Phlegrean fields of Italy and that district with a portion of the surface of the moon; but there is a distinct difference between the aspect of the surface of the Rotorua district and that of the Phlegrean fields. They are both volcanic; but in the Italian district, as all those know who have been to Italy, there is a preponderance of crater features, while in the Rotorua district that preponderance of craters is less conspicuous. That, I think, is entirely due to the fact of the great preponderance of acidic rocks in the New Zealand area, which gives such large deposits of pumaceous ejectamenta and of siliceous sinter from the boiling springs, and this interferes very much with the crater-like character of the area.

There is another point that has never been noticed, as far as I am aware, and it is of great interest, namely, the long continuance of volcanic action on the New Zealand area, the volcanic action of the Neapolitan volcanic and those of Sicily and the Lipari islands. All those volcanic hills and craters have had their origin within the Pliocene period; whereas the volcanic action has continued in New Zealand from before Tertiary times; for the newest volcanic rocks of the South Island are overlaid by Tertiary rocks; so that we have evidence of a very long continuance of volcanic action in the New Zealand region which continues into the present time. This volcanic action, in one part of this paper, is said to be scarcely a true volcanic action because there was no lava in the eruption of 1886. But it does not follow at all that the

action is not truly volcanic because there is no lava. Many of the greatest eruptions that have taken place in the world have been entirely devoid of lava flows. The great eruption of A.D. 79, which destroyed Pompeii and Herculaneum, was entirely without lava, and the recent West Indian eruptions were entirely destitute of lava flows.* These are explosive eruptions in which the whole of the lava has been converted into fragmentary ejectamenta. So that the absence of lava is no indication of want of true volcanic action.

The fact of these eruptions in New Zealand being chiefly explosive and without lava-flows is due, I think, to the fact that the rocks are chiefly acidic (or siliceous) and to there being a great access of water to the rising lava, and so converting the whole into ejectamenta of a dry solid character which otherwise, without a sufficient amount of water, would have partly flowed away in liquid lava.

There are a great many points that are suggestive of remark, but I will not occupy your time further.

The CHAIRMAN.—I think we have a gentleman here who has been to the Lipari Islands, Mr. Narlian.

Mr. NARLIAN.—What I have seen of the photographs reminds me very much that all the formations I have seen are very much like what we have had at Nilcano. Again, as the Professor has observed, in all acidic formations there is an absence of lava-flow. The last great eruption we had was absolutely devoid of all lava-flow. The vapour and fumes were highly charged with electricity, and the column ejected might have been 15,000 feet as well as we could measure. Of course it was not all charged with water, but the shaft and small bits perhaps of rock went up, in many cases, 15,000 feet. Estimating the height of the mountain from the level of the sea, and taking the proportion of the column ejected from the crater, I could not take it under that measure. Some of the great boulders ejected were a good deal more than the size of this room, and were ejected to a distance of 1 or $1\frac{1}{2}$ miles, and a great many of them have been spread over the island.

I believe in other cases, also, a terrace-like formation is found.

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* "Volcanic action and the West Indian eruptions of 1892," *Trans. Vict. Inst.*, vol. xxxv, p. 214 (1903), also the same subject by Prof. J. W. Spencer, *ibid.*, p. 198.

The SECRETARY.—Have some of those terraces been raised out of the sea ?

Mr. NARLIAN.—No ; from the sea the formation of the mountain is very abrupt—something like, perhaps, 45 degrees.

The SECRETARY.—I think I ought to join, with Professor Logan Lobley and yourself, sir, in expressing our obligation to Miss Boord for this exceedingly interesting and graphic paper which she has read before us. She has given us an account of the phenomena she witnessed in this wonderful island, in a clear, lucid and agreeable manner, and I could see from the manner in which the audience were following her in the paper that they were all very much interested in her observations. We, in this happy island of ours, are not so favoured as some other countries in regard to recent volcanic phenomena, though we have grand representatives of extinct volcanic action. We have no eruptions from craters, no geysers and very seldom any earthquakes that we are conscious of ; so that we are dependent on travellers to Iceland, Yellowstone Park, the Lipari Islands, the West Indies and other regions of the globe for accounts of these grand operations of nature ; the results of heat and moisture acting with tremendous force through the agency of steam, producing wonderful effects at the time and leaving their marks for many a day afterwards. We are, therefore, indebted to those who bring us information and produce before us pictures and photographs of the phenomena they have seen like those exhibited here to-day, and which, after all, though beautifully representative, yet fall very far short indeed of the phenomena themselves as seen in nature. For these reasons I think we are very much indebted to Miss Boord for her paper.

The CHAIRMAN having put the vote of thanks to the Meeting, which was carried unanimously, Miss BOORD, through the Chairman, thanked the Meeting for the manner in which her paper had been received, and the proceedings terminated.